

Quark Matter

System and energy dependence of strange and non-strange particle correlations in STAR at RHIC

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Abstract. Two-particle high- p_T triggered correlations in $Cu + Cu$ and $Au + Au$ collisions at $\sqrt{s_{NN}} = 62 \text{ GeV}$ and $\sqrt{s_{NN}} = 200 \text{ GeV}$ in STAR at RHIC are presented. The N_{part} , $p_T^{associated}$, and $p_T^{trigger}$ dependence of the yield per trigger in the *Jet* and *Ridge* components of the near-side is investigated for h , K_S^0 , Λ , and Ξ trigger and associated particles. The system and energy dependence of these components is a potentially powerful tool to distinguish between models used to describe their production.

1. Data analysis and results

Previous studies in $Au + Au$ collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$ demonstrated that the near-side peak in high- p_T triggered correlations can be decomposed into two structures. The *Jet* is narrow in both azimuth ($\Delta\phi$) and pseudorapidity ($\Delta\eta$), similar to what is observed in $d + Au$, while the *Ridge* is narrow in azimuth but broad in pseudorapidity. The *Jet* component is similar to that expected from vacuum fragmentation, whereas the *Ridge* has properties similar to the bulk[1, 2]. Comparing data from $Au + Au$ and $Cu + Cu$ collisions at $\sqrt{s_{NN}} = 62 \text{ GeV}$ and $\sqrt{s_{NN}} = 200 \text{ GeV}$ tests whether these conclusions are robust.

Several mechanisms have been proposed for the production of the *Ridge* [3, 4, 5, 6]. These models have yielded few calculations which can be directly compared to data, in part because of the number of factors which must be considered when theoretically calculating the experimentally measured quantities. These data should provide a good test of models for the production of the *Jet* and *Ridge* because trends expected with changing collision energy and in nuclei collided in a given model should be easier to calculate theoretically.

The distribution of associated particles relative to a high- p_T trigger particle in azimuth ($\Delta\phi$) and pseudorapidity ($\Delta\eta$) is normalized per trigger. The elliptic flow (v_2) modulated background is subtracted assuming a two-component model and using the Zero-Yield-At-Minimum (ZYAM) method[7]. The background is set by averaging over three points near the minimum at $\Delta\phi \approx 1$. The validity of this assumption is checked by comparing to the ZYAM method with one point and by allowing the background level

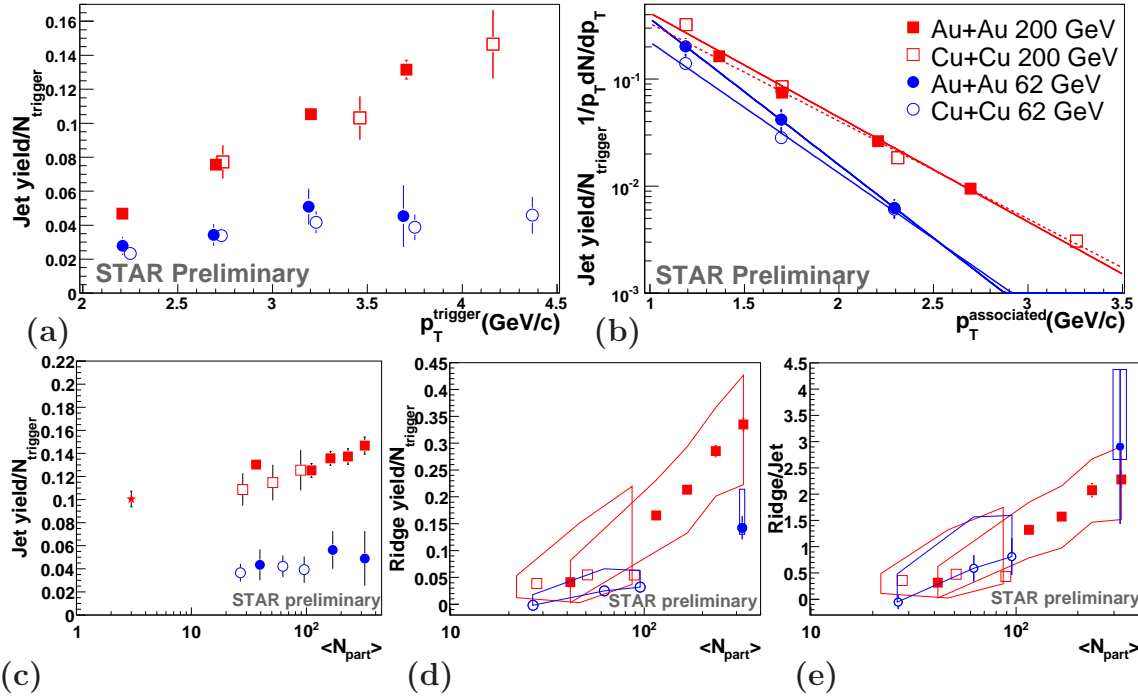


Figure 1: Energy and system dependence of yields for h-h correlations. Dependence of *Jet* yield on (a) $p_T^{trigger}$ (b) $p_T^{associated}$ (c) N_{part} , (d) *Ridge* yield on N_{part} (e) *Ridge/Jet* on N_{part} . $3.0 < p_T^{trigger} < 6.0$ GeV/c except for (a) and 1.5 GeV/c $< p_T^{associated} < p_T^{trigger}$ except for (b). Data from the fits in (b) are shown in table 1. Colour online.

to vary in a fit. All correlations are corrected for the detector efficiency of the associated particle. The *Ridge* yield is given for $|\Delta\eta| < 1.75$ and $|\Delta\phi| < 1$ and the *Jet* yield is extracted in the range $|\Delta\eta| < 0.75$. The K_S^0 , Λ , and Ξ are identified by reconstruction of their decay vertices in the STAR TPC. [8] provides a more complete description of both yield extraction and particle identification. Unless otherwise noted, 1.5 GeV/c $< p_T^{associated} < p_T^{trigger}$ and $3.0 < p_T^{trigger} < 6.0$ GeV/c. The data from Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV are from [1].

A systematic error due a detector effect, discussed in greater detail in [9], which causes lost tracks at small $\Delta\phi$ and small $\Delta\eta$ has not yet been taken into account. This effect, on the order of 10%, is greater in higher multiplicity environments, at lower $p_T^{associated}$ and $p_T^{trigger}$, and for particles identified by the reconstruction of decay vertices, and therefore reduces the *Jet* yield more for K_S^0 and Λ than h and more in Au + Au than in Cu + Cu collisions. The degree of correlation between systematic errors on the *Ridge* yield for different particle species due to v_2 is still being studied. These systematic errors affect both identified trigger and associated particle studies.

The *Jet* yield per trigger is shown as a function of $p_T^{trigger}$ in figure 1a, as a function of $p_T^{associated}$ in figure 1b, and as a function of N_{part} in figure 1c. The *Jet* yield at $\sqrt{s_{NN}} = 62$ GeV is considerably lower than that at $\sqrt{s_{NN}} = 200$ GeV. However, similar features are observed at both energies; the *Jet* yield rises with $p_T^{trigger}$, decreases steeply with $p_T^{associated}$, and is independent of N_{part} . The data in table 1 demonstrate that the Cu + Cu and Au + Au inverse slope parameters are within error at the same $\sqrt{s_{NN}}$

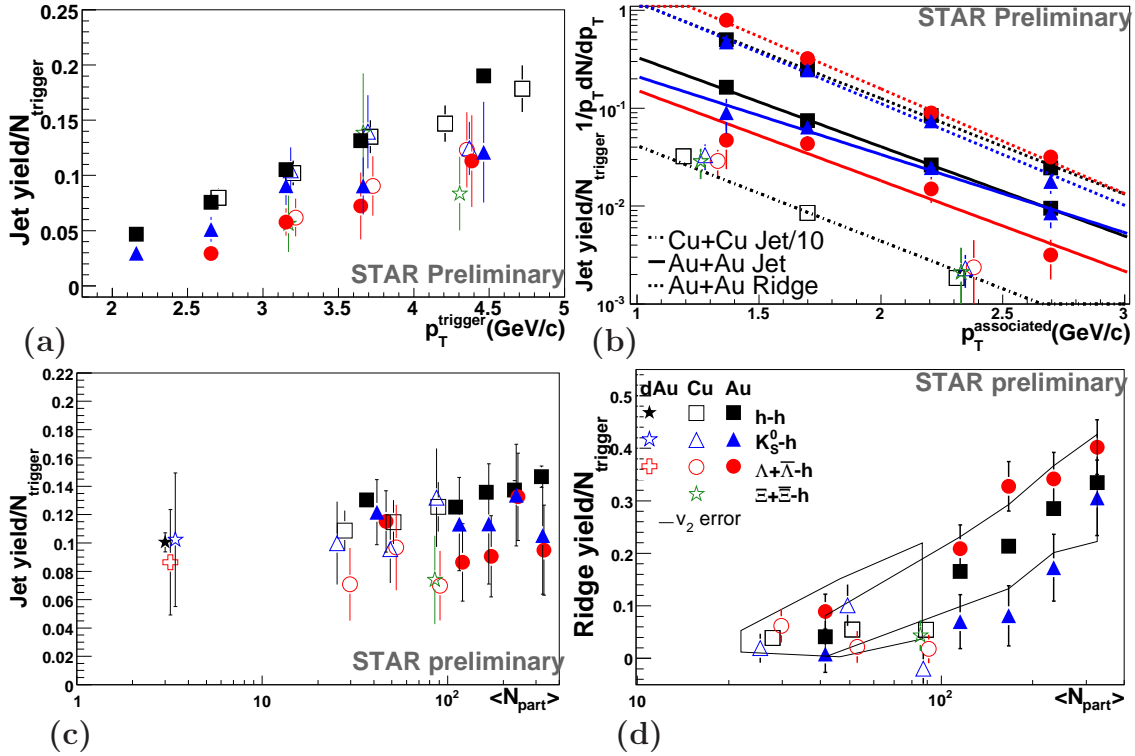


Figure 2: System and particle type dependence at $\sqrt{s_{NN}} = 200$ GeV for identified trigger particles. (a) Dependence of *Jet* on p_T^{trigger} for $1.5 \text{ GeV}/c < p_T^{\text{associated}} < p_T^{\text{trigger}}$ (b) Dependence of *Jet* and *Ridge* on $p_T^{\text{associated}}$ for $3.0 < p_T^{\text{trigger}} < 6.0 \text{ GeV}/c$ (c) Dependence of *Jet* on N_{part} (d) Dependence of *Ridge* on N_{part} . Data from the fits in (b) are shown in table 1. The systematic errors due to v_2 are comparable to those shown for unidentified triggers for K_S^0 triggers and roughly 3/2 times larger for Λ and Ξ [1, 8]. Colour online.

and N_{part} . The *Ridge* yield as a function of N_{part} is shown in figure 1d. The *Ridge* yield increases dramatically with N_{part} for both energies. Although the magnitude of the yield of both the *Jet* and the *Ridge* are considerably smaller at $\sqrt{s_{NN}} = 62$ GeV, figure 1e shows that *Ridge*/*Jet* is roughly independent of energy.

Figure 2 shows the yields with identified trigger particles at $\sqrt{s_{NN}} = 200$ GeV. The dependence of the *Jet* yield on p_T^{trigger} , $p_T^{\text{associated}}$, and N_{part} , shown in figure 2a, b, and c, respectively, may indicate a slightly lower yield for Λ and K_S^0 . However, the systematic error due to tracking inefficiencies for close pairs, which is greater for Λ and K_S^0 triggers than for h, may be sufficient to explain the observed difference. Figure 2b and figure 2d show the dependence of the *Ridge* on $p_T^{\text{associated}}$ and N_{part} , respectively; these data may indicate a slightly higher yield for Λ and a slightly lower yield for K_S^0 triggers. However, the data are within error for all trigger species and the degree of correlation of errors for different trigger particle species is still under study. Therefore, within our current understanding of the errors, there is no significant dependence on the trigger particle species in either *Cu + Cu* or *Au + Au* collisions. The independence of the inverse slope parameters in table 1 on particle species further supports no trigger type dependence.

Figure 3 shows the yields with identified associated particles at $\sqrt{s_{NN}} = 200$ GeV.

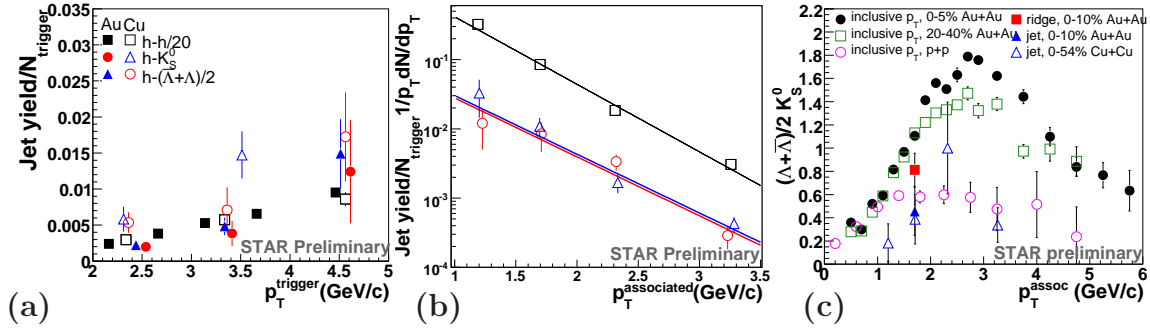


Figure 3: System and particle type dependence of the *Jet* at $\sqrt{s_{NN}} = 200$ GeV for identified associated particles. (a) Dependence on $p_T^{trigger}$ for $1.5 \text{ GeV/c} < p_T^{associated} < p_T^{trigger}$ (b) Dependence of $p_T^{associated}$ for $3.0 < p_T^{trigger} < 6.0 \text{ GeV/c}$ (c) Particle ratios in the *Ridge* and *Jet* as compared to the inclusive particle ratios. Data from the fits in (b) are shown in table 1. Colour online.

Table 1: Inverse slope parameter k (MeV/c) of $p_T^{associated}$ for fits of data in Figure 1(b), Figure 2(b), and Figure 3(b) to $Ae^{-p_T/k}$. The inverse slope parameter from a fit to π^- in $Au + Au$ from [10] above 1.0 GeV/c is $k = 280.9 \pm 0.4$ MeV/c for $\sqrt{s_{NN}} = 62$ GeV and is $k = 330.9 \pm 0.3$ MeV/c for $\sqrt{s_{NN}} = 200$ GeV. Statistical errors only.

	62 GeV	200 GeV				
	h-h	h-h	K_S^0 -h	$\Lambda + \bar{\Lambda}$ -h	h- K_S^0	h- $\Lambda + \bar{\Lambda}$
Au <i>Ridge</i>		438 ± 4	406 ± 20	416 ± 11		
Au <i>Jet</i>	317 ± 26	478 ± 8	530 ± 61	445 ± 49		
Cu <i>Jet</i>	355 ± 21	445 ± 20			505 ± 87	510 ± 55

The dependence on $p_T^{trigger}$ shown in figure 3a and on $p_T^{associated}$ in figure 3b for $Cu + Cu$ and $Au + Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV are similar for both K_S^0 and $\Lambda + \bar{\Lambda}$ to that observed for unidentified hadrons, although the magnitude is considerably smaller. The baryon to meson ratios in the *Ridge* in $Au + Au$, the *Jet* in $Au + Au$ and $Cu + Cu$, and the inclusive spectra in $Au + Au$ and $p + p$ are compared in figure 3c. The baryon to meson ratio in the *Ridge* is within error of that of the inclusive ratio in $Au + Au$ while the baryon to meson ratios in the *Jet* in $Au + Au$ and $Cu + Cu$ are comparable to that in $p + p$.

2. Conclusions

The measured *Jet* and *Ridge* yields in $Cu + Cu$ and $Au + Au$ collisions are within error at the same $\sqrt{s_{NN}}$ and N_{part} , indicating no dependence on geometry. The *Jet* yield at $\sqrt{s_{NN}} = 62$ GeV is smaller than at $\sqrt{s_{NN}} = 200$ GeV, as expected from the steeper spectrum in $\sqrt{s_{NN}} = 62$ GeV [11]; the observation that the *Ridge*/*Jet* ratio is roughly independent of energy is potentially a powerful way to distinguish models. No dependence on the trigger particle identity is observed. Baryon/meson ratios in *Jet* and *Ridge* and the differences in the associated particle spectra suggest that the *Jet* has

properties similar to $p + p$, whereas the properties of the *Ridge* are closer to the bulk.

- [1] Bielcikova J (STAR) 2007 *J. Phys. G: Nucl. Phys.* **34** S929-932
- [2] Putschke J (STAR) 2007 *J. Phys. G: Nucl. Phys.* **34** S679-683
- [3] Armesto N, Salgado C, and Wiedemann 2005 *Phys. Rev.* **C72** 064910
- [4] Wong C 2007 *Phys. Rev.* **C76** 054908
- [5] Hwa R, and Chiu C 2005 *Phys. Rev.* **C72** 034903
- [6] Voloshin S 2006 *Phys. Lett.* **B632** 490
- [7] Adams J *et al* (STAR) 2005 *Phys. Rev. Lett.* **95** 152301
- [8] Nattrass C (STAR) 2008 *J. Phys. G: Nucl. Phys.* **35** 044063
- [9] Bombara M (STAR) 2008 *J. Phys. G: Nucl. Phys.* **35** 044065
- [10] Abelev B *et al* (STAR) 2007 *Phys. Lett.* **B655** 104
- [11] Filimonov K (STAR) 2005 *J. Phys. G: Nucl. Phys.* **31** S513-S520